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Compost Addition on Polluted Soils to Ensure Fruit and Vegetable Safety

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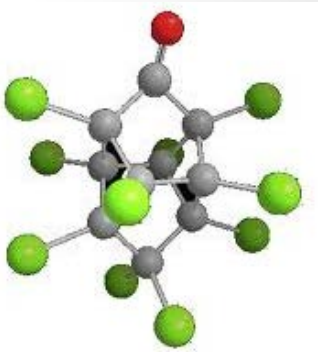
Context of pollution by chlordecone (CLD)



- Persistent insecticide that was intensively used in banana cropping systems (1971→ 1993)
  - Physicochemical properties:
    - low solubility in water (S<0,5 mg/L),
    - high affinity for organic matter (log Koc >3,5)
  - Poor biodegradability related to its peculiar chemical structure (bishomocubane) with high steric hindrance (half life 4 - 45 years).

☞ **Natural decontamination would take decades / centuries**

(Cabidoche et al, Environ. Pollution, 2009)

- About 10 000 ha polluted at different levels

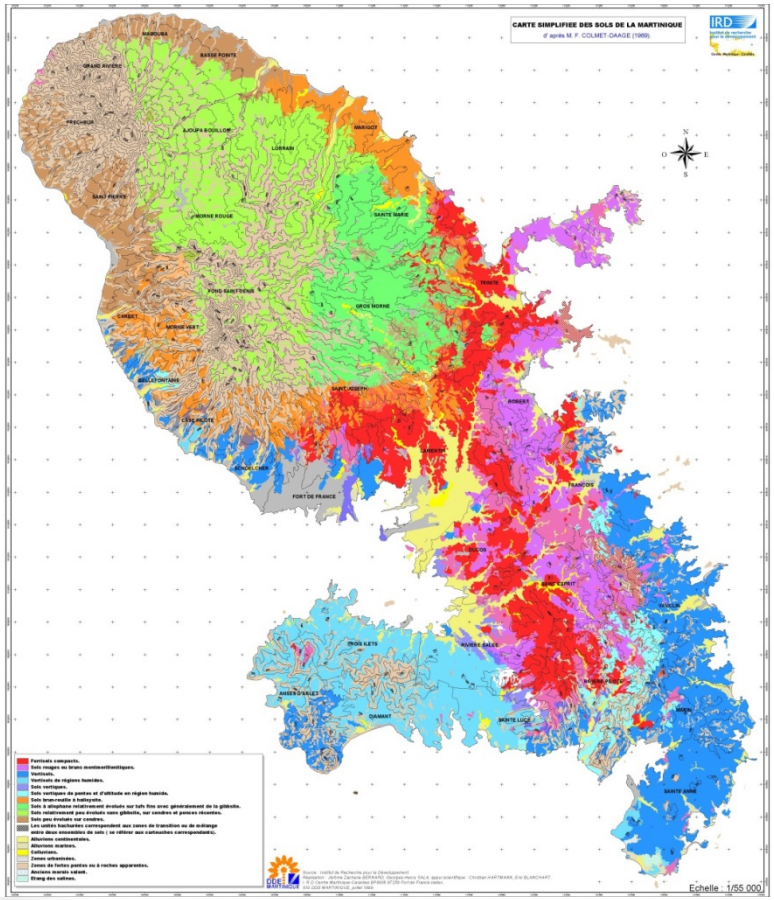
☞**Need for efficient cost-effective *in situ* treatments.**

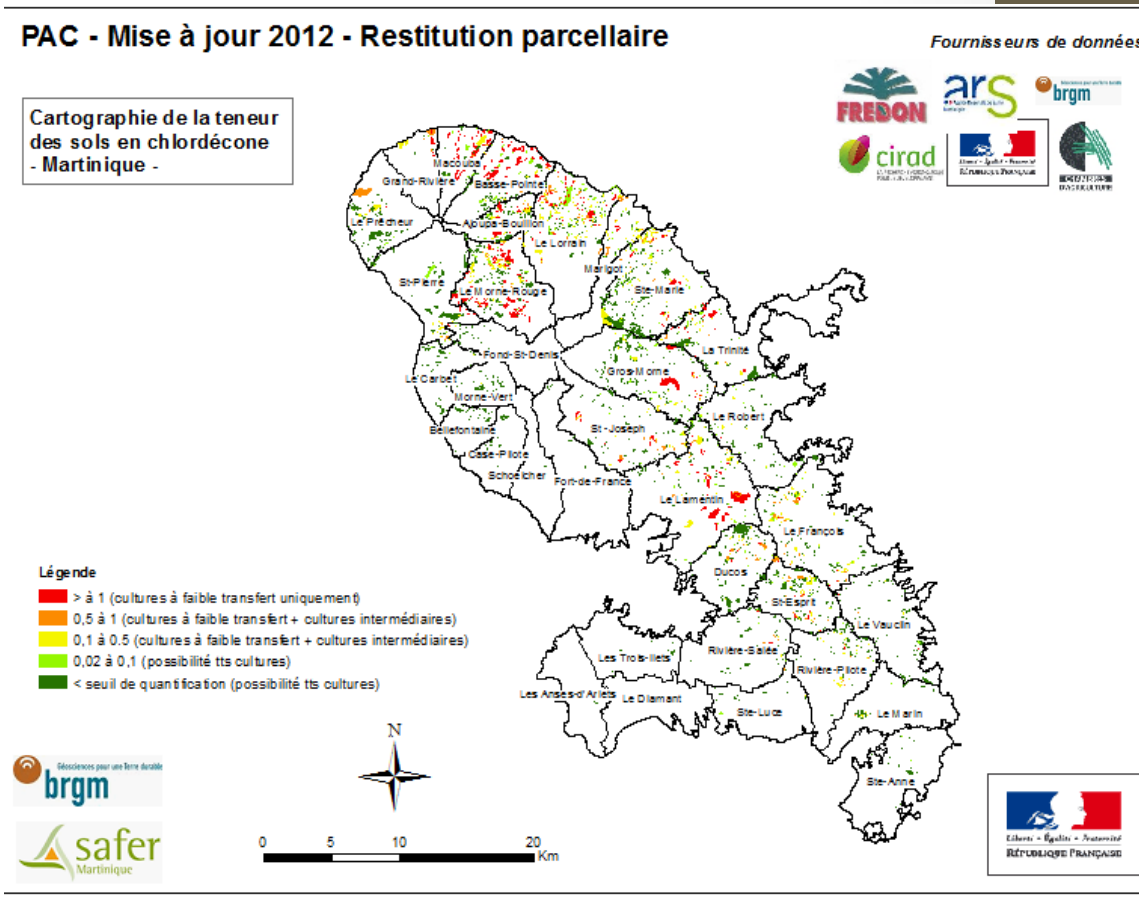
To date, phytoextraction *(Topp et al, Ecotoxicol Environ Saf, 1986)*

and microbial degradation *(George and Claxton, Xenobiotica, 1988 ; Orndorff and Colweel, Allpl Environ Microbiol., 1980)*

have not really been efficient in the case of diffuse pollution of chlordecone in the soil.

Soil types and polluted areas in Martinique

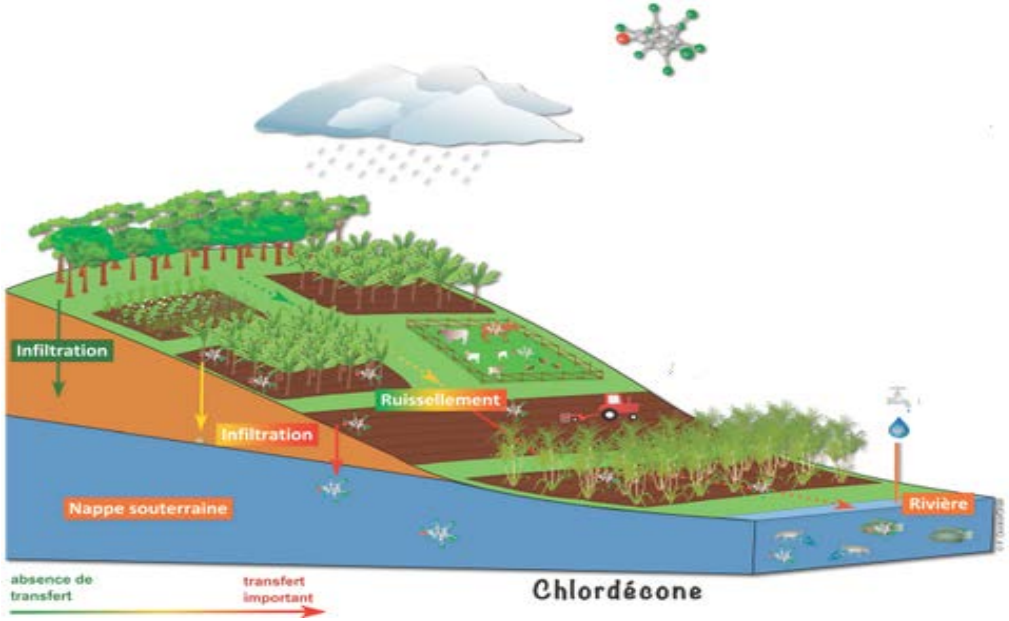




- Andosols and nitisols are the two main contaminated soil types, they are still the pollution reservoir

CLD permanently pollutes soils…..

- …and consequently continues to contaminate crops, water resources, and food chains



☞ Consequences on human health, chlordecone is suspected to :

- be implicated in the increasing incidence of prostate cancer
  (Multigner et al, J Clin Oncol., 2010)
- impair development of young children
  (Boucher et al, Neurotoxicol., 2013 ; Dallaire et al, Envir. Res., 2012)

☞The release of chlordecone from polluted soils to food chains needs to be controlled to reduce contamination of food and populations.

CLD sequestration by organic matter : dream or real alternative ?

- Our main hypothesis

☞ **sequestering chlordecone in the soil = an alternative to reduce its availability for crops and water resources.**

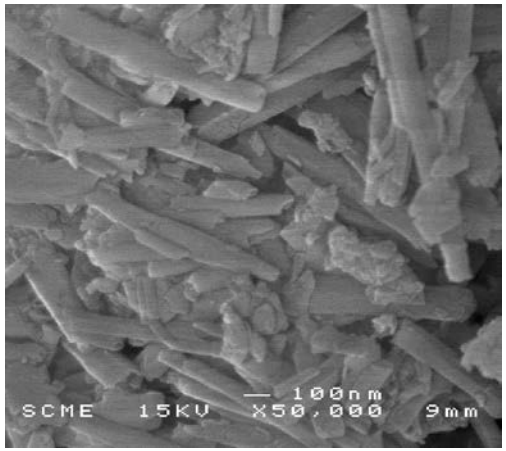
- Our objectives
  1. To confirm that adding organic matter reduces CLD contamination of the environment
  2. To discuss the role of pore microstructure in the ability of a soil to trap CLD
  3. To assess the feasibility for farmers

- We then chose to study the ability of organic matters to sequestrate this molecule in the two main contaminated soil types presenting different characteristics:
  - andosols, with amorphous clays (allophane),
  - and nitisols, with crystalline 1/1 clays.

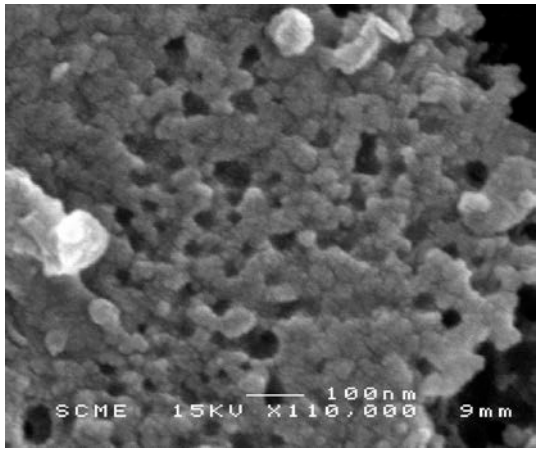
Testing the sequestration efficiency on 3 crops

Material and methods overview

Non allophanic soil



Allophanic soil



+

5% w/w

	Organic fertilizer	Organic amendment
Water content	47 %	24.8 %
Organic matter content	20.6 %	46.6 %
Humic yield (CBM)	49 kg C t^{-1} of fresh product	577 kg C t^{-1} of fresh product
Humifying capacity (k_1)	0.11	0.70

- CLD contamination of crops
- Evolution of soil microstructure
- Agricultural practice recommandations

The chosen crops:

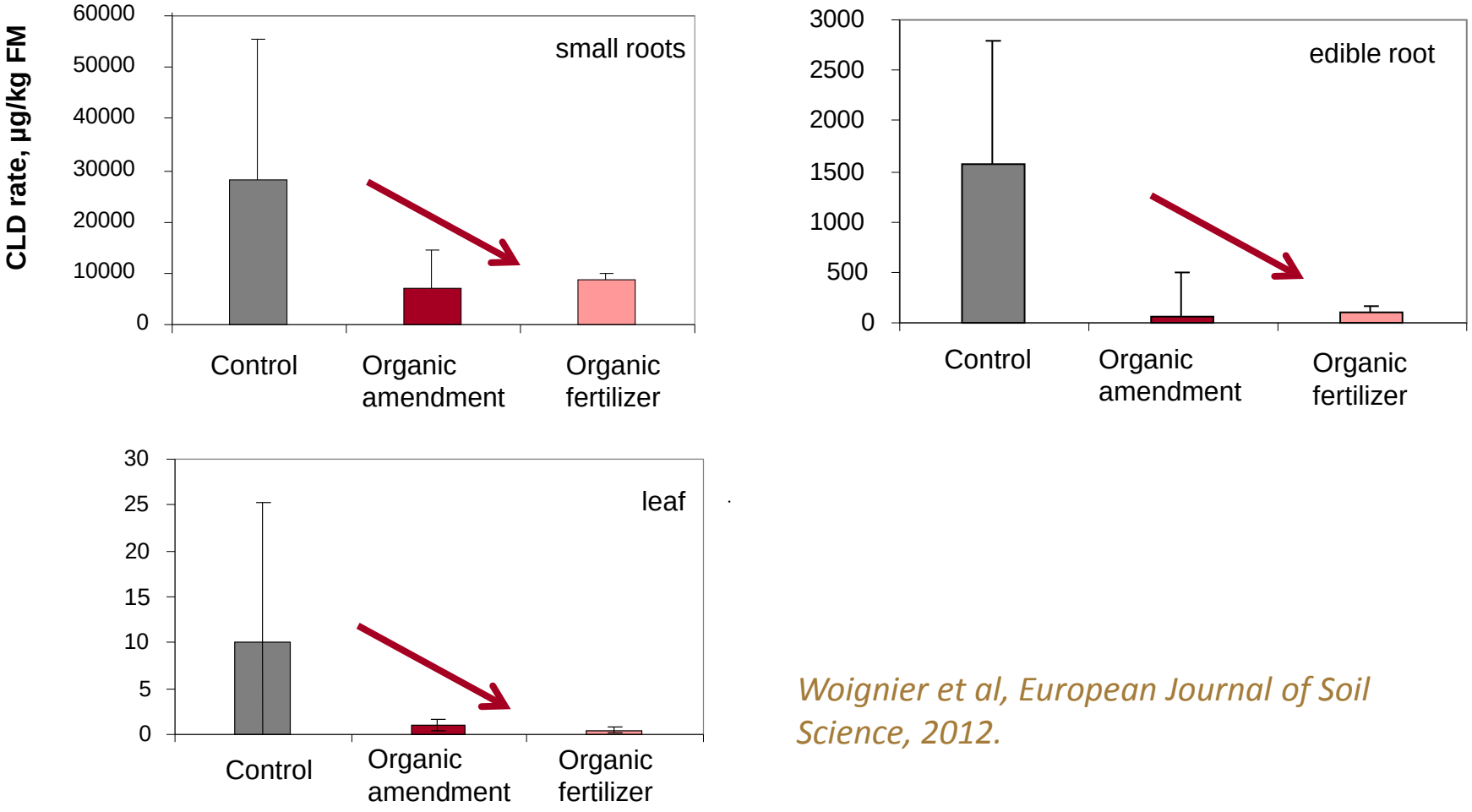
Crop	Radish	Cucumber	Lettuce
Edible part	Tuber	Fruits	Leaves
Model for	Root and tuber	Cucurbits	Leaf crops
Crop cycle duration	30-35j	45-55j	30-35j

Cucumber is also a high contributor to people exposure *(Dubuisson et al, 2007)*

- On radish several parts of the plant were analyzed:
  - fine roots
  - Tuber
  - Leaves
- Transfer ratio : $\frac{\text{crop CLD content}}{\text{soil CLD content}}$ $\left(\frac{\mu g.kg^{-1}\ FM}{\mu g.kg^{-1}\ DS}\right)$

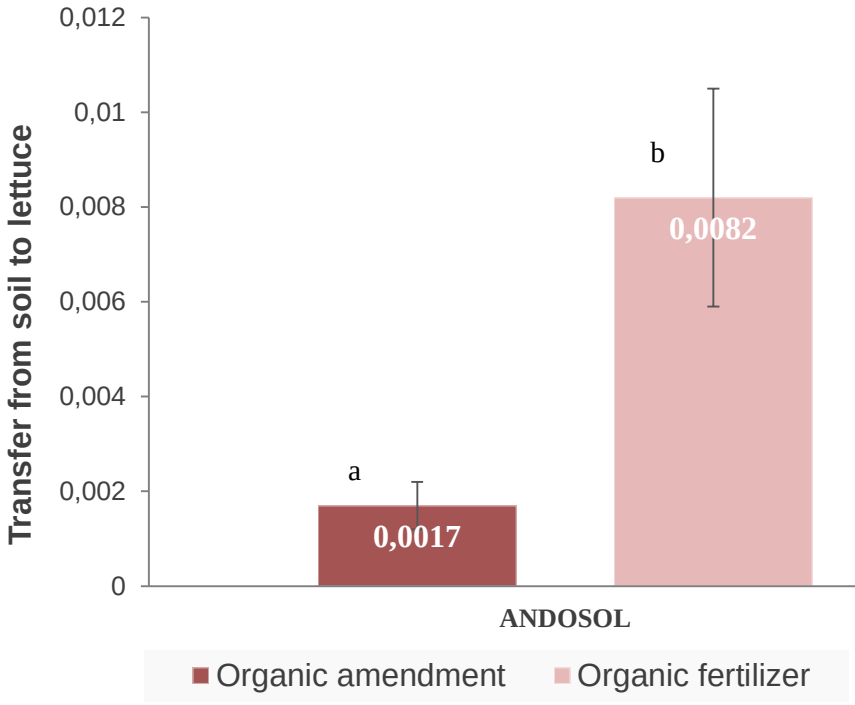
Added OM drastically reduced crop contamination by CLD

Chlordecone content (µg/kg of fresh material) of radish cultivated on contaminated andosol, 3 months after OM addition - pot experiment



Woignier et al, European Journal of Soil Science, 2012.

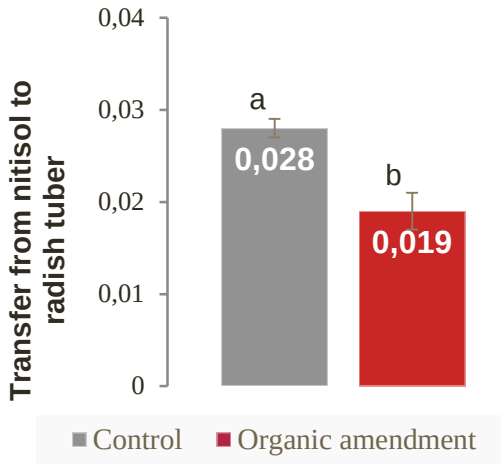
Added OM initial quality has an impact on the duration effect

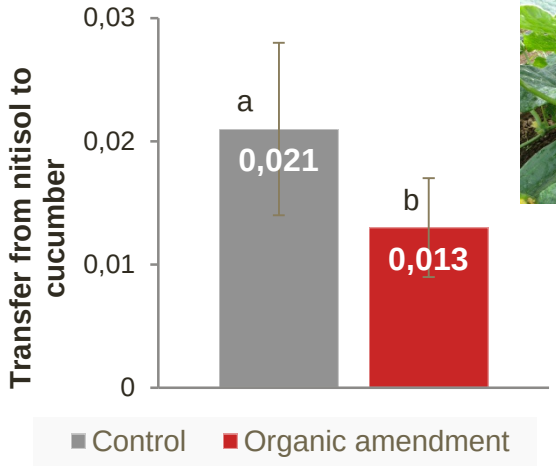


- No more significant effect on CLD contamination with the organic fertilizer 6 months after addition - pot experiment
- Only the organic amendment still reduces the crop contamination (5 fold)

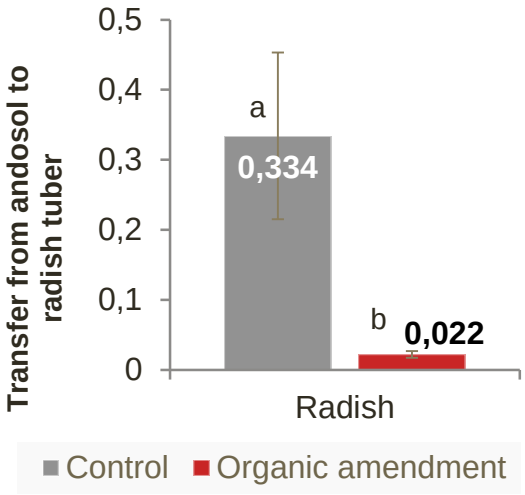
☞**focus on the organic amendment for the field evaluations**

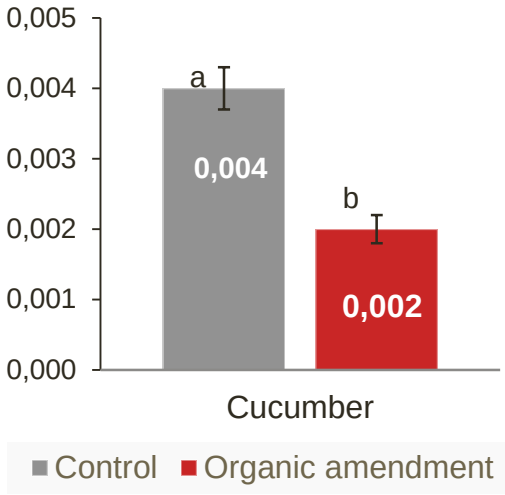
CLD transfer between 3 and 6 months after OM incorporation at field scale





NITISOL





ANDOSOL

- Organic amendment reduces significantly CLD contamination but with lesser amplitude (1,4 to 15 fold)

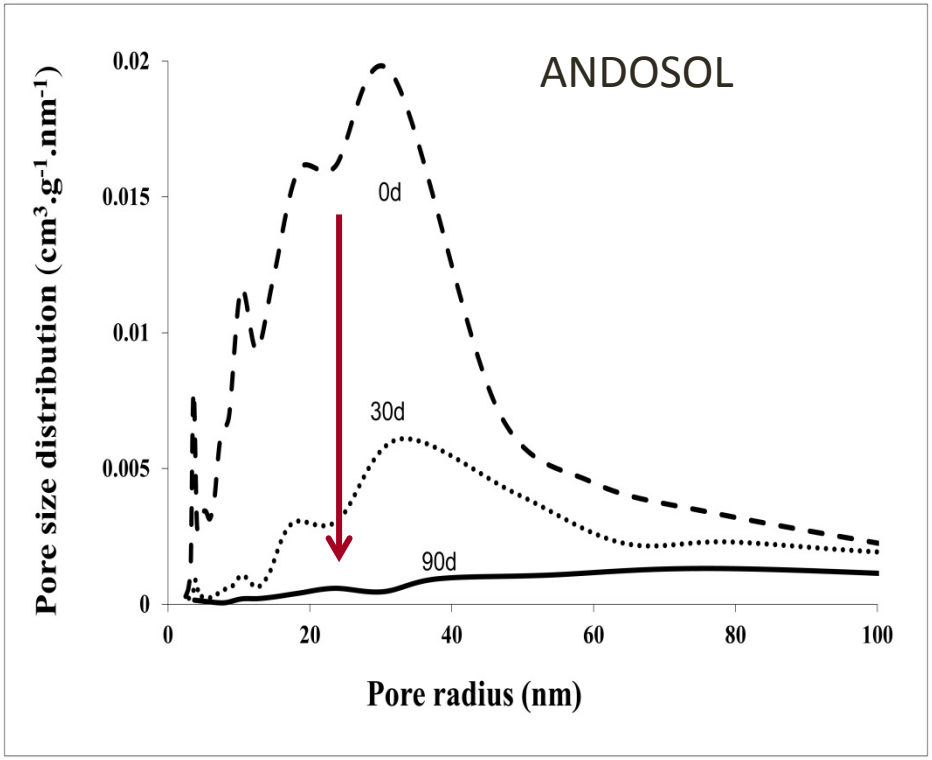
Woignier et al, Fertilizer Technology vol 2, in press

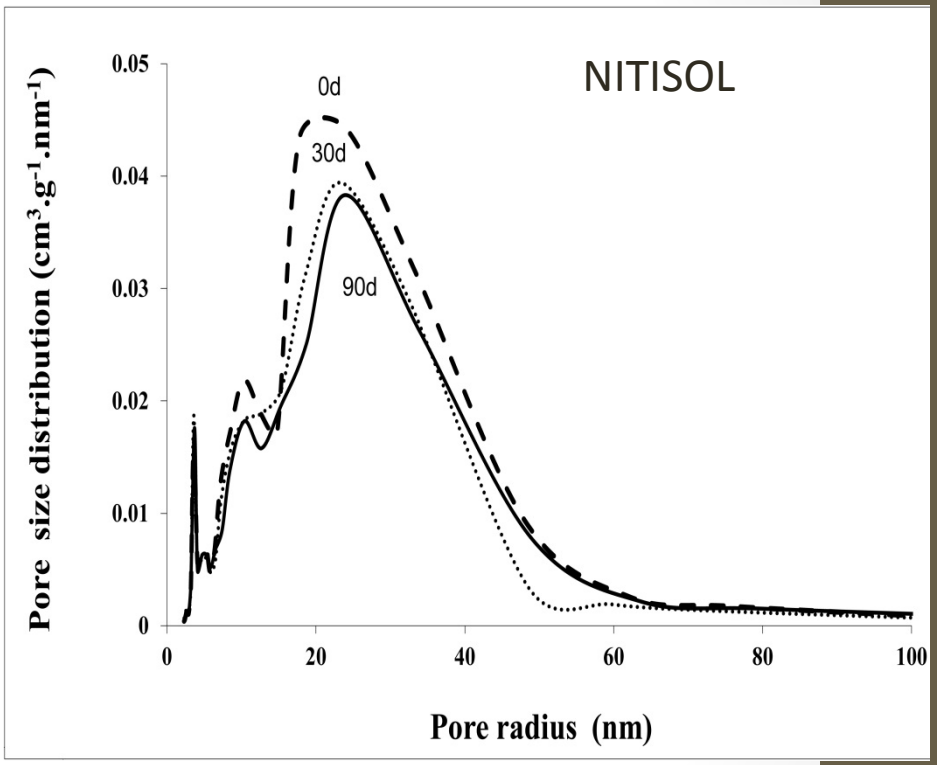
Efficiency of the OM addition

- Increased in allophanic soil

crop	radish	lettuce	concumber
Normalized transfer rate (%) with compost addition	7	23	51

Added OM reduced mesopore volume in andosols but not on nitisols





- The mesoporosity of andosol decreased with added OM.
  - After 30 days: pore size distribution ↘ to 1/3 of that at day 0 = pore closure in the range of 10 to 80 nm.
  - After 90 days, the pore size distribution still strongly affected by both composts (loss of 80% of the mesopores).
- No change in the porosity of non allophanic soil

Woignier et al, Fertilizer Technology vol 2, in press

Consequences on the soil properties

- On allophanic soil: mainly physical effect
  - Contraction of the soil aggregates
  - ↘ in the soil mesopore volume (10-50 nm)

Lead to

- ↗ in the internal capilary tensions and ↘ in the transport properties (hydraulic conductivity, diffusion)
- **Pesticide trapping ↗**
- **pesticide availability to water and thus plants ↘**

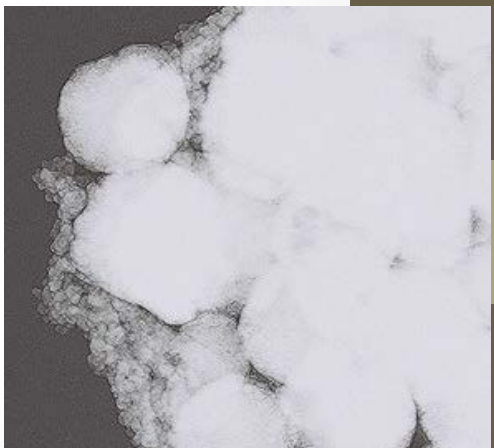
- On non allophanic soil: mainly chemical effect
- ↗ OM in soil leads also to **increased chemical bounds between pesticide and OM**

Practice recommandations

- Add compost is a common practice in horticulural cropping systems
- But
  - The quantity has to be adjust with the soil CLD content and soil type (pb of cost)
  - The duration of the sequestration effect has to be better assessed

Take home message

- Added OM can reduced crop contamination
- The intensity and duration of this effect depend on
  - initial pollutant concentration in soil
  - biochemical composition of added OM
- Added OM act like a chemical attractant in nitisol (1/1 clay)
- Added OM induced a dramatic collapse of mesoporosity on andosol
  - CLD physically trapped in a closed labyrinth



Special thought to….

our highly estimated colleagues

- **Yves-Marie Cabidoche** (✞ 2012), soil researcher at INRA Guadeloupe, pionnier in the chlordecone working group
- **Jacky Ganry** (✞ 2012), agronomist at Cirad, pionnier in the integrated management of banana cropping systems

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☞ for supporting this pluriannual research program

A interdisciplinary research group…

…working in an attractive scientific platform ….located in a beautiful environnement…

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Thanks for your attention ! Any questions ?